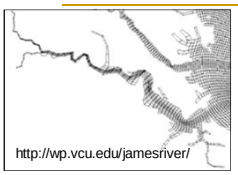
Meeting of the Stakeholder Advisory Group

James River Algal Blooms Study



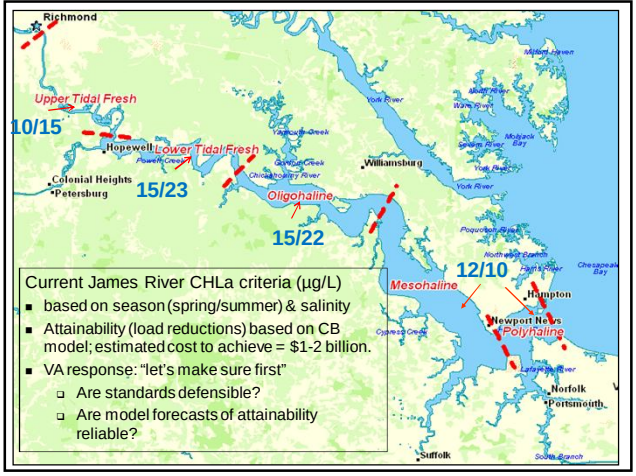
Paul Bukaveckas
September 15, 2014

VCU Rice Rivers Center

Science Advisory Panel on Data and Modeling Needs for Assessing Numeric CHLa Criteria of the James River Estuary

Panel Members

Clifton F. Bell	Claire Buchanan
Brian Benham	Paul Bukaveckas*
Greg Garman	Eileen E. Hoffman
Will Hunley	Rebecca LePrell
Winston Lung	Todd Egerton
Kenneth Moore	Margaret Mulholland
Kimberly S. Reece	Peter Tango
Harry V. Wang	*Panel Leader



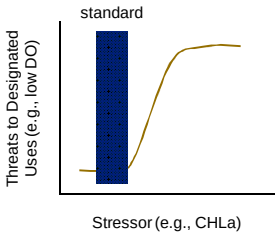
Project Status

- 2012-2013: data collection and model-building activities
- 2014: data analyses and model calibration
- 2015: panel recommendation to DEQ on need to revise CHLa standards; model simulations to assess attainability.

Are current CHLa criteria protective of designated uses?

- What are the threats to designated uses?
  - Objective 1: identify metrics indicative of detrimental effects caused by algal blooms (e.g., low DO, algal toxins).
- Does the risk vary with CHLa?
  - Objective 2: for each metric, relate probability of exceeding threshold to CHLa.
- Will attaining the CHLa criteria mitigate risk?
  - Objective 3: for each metric, assess probability of exceeding threshold when CHLa criteria are attained.

Stressors & Impairment (Theory)



Candidate Metrics for assessing threats to designated uses:

- Phytoplankton Community Metrics
  - (basis for current CHLa standard) intended to meet a statewide use designation calling for a "balanced, indigenous population of aquatic life in all waters" (DEQ 2004).
  - Potential metrics: community evenness, IBI scores (e.g., vs. reference conditions), abundance of harmful algae.
- Water Quality Metrics
  - Linking algal blooms to deterioration in water quality (DO, pH, transparency, algal toxins).

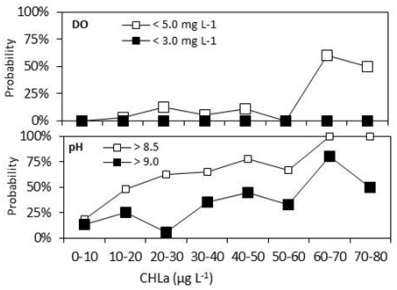
General Approach: relating risk to CHLa

- Define metrics and thresholds of interest (e.g., DO < 5 mg/L; pH > 9).
- Calculate the probability of exceeding thresholds in relation to CHLa measurements grouped into ranges (e.g., 0-10, 10-20 µg/L).
- Derive combined probability of exceeding threshold at a given CHLa, and probability of occurrence for that CHLa range at attainment.

CHLa	p (DO<5)	p (CHLa)	p (combined)
0-30	1%	50%	0.5%
31-60	10%	35%	3.5%
61-90	50%	15%	7.5%

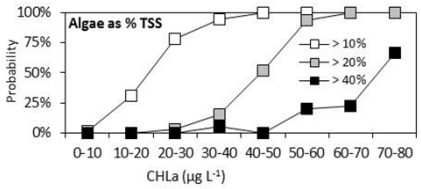
Sum = 12%

Results: Tidal Fresh – DO and pH



Probability of exceeding nighttime DO minima and daytime pH maxima in relation to CHLa. DO and pH from continuous monitoring; CHLa (extracted) from weekly monitoring.

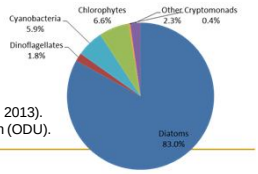
CHLa & Water Clarity



Algal contributions to water clarity in the tidal-fresh James based on their proportional contribution to suspended particulate matter (TSS). Data shown are probability of exceeding specified threshold values.

CHLa & Algal Toxins

- The phytoplankton community in the tidal fresh James includes a small complement of cyanobacteria (blue-green algae).
- These algae produce a toxin (Microcystin) that poses a potential threat to designated uses (drinkability, swimability, fishability, aquatic life).
- How do we assess risks to designated uses?



Phytoplankton of tidal-fresh James (Summer 2013). Data from Todd Egerton (ODU).

CHLa & Algal Toxins (Microcystin)

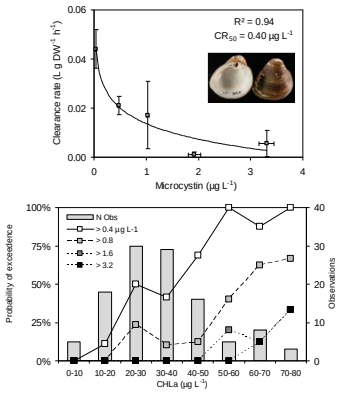
- Using human health end points (e.g., WHO drinking and recreational contact standards) to assess risk is not useful because MC levels in the James have rarely (drinking) or never (contact) exceeded these standards during the period of monitoring (risk of impairment too low to assess with available data).
- For aquatic life, LC50's for aquatic invertebrates are orders of magnitude higher (~ 100's – 1000' µg/L; Smith et al. 2008) than are observed in the James (~1-10 µg/L). Mortality effects are unlikely.
- What about sub-lethal effects?

Assessing MC Thresholds

Approach #1: effects on ecosystem services provided by benthic filter-feeders.

Top: effects of exposure to dissolved Microcystin on clearance rates of Rangia.

Bottom: likelihood of exceeding Microcystin concentrations at various levels of CHLa.



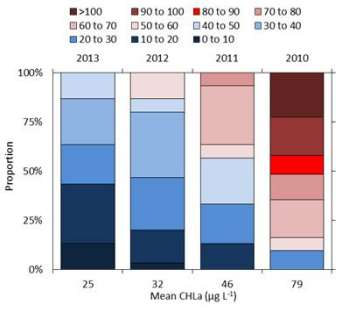
CHLa Criteria

All metrics for tidal-fresh show relationships with CHLa and therefore support the view that CHLa criteria can be used to assess attainment of designated uses.

Next step: using these relationships to assess risk with changing CHLa (e.g., at attainment).

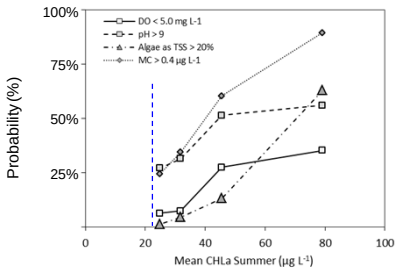
CHLa	p (DO<5)	p (CHLa)	p (combined)
0-30	1%	50%	0.5%
31-60	10%	35%	3.5%
61-90	50%	15%	7.5%

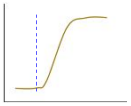
CHLa Distribution



Proportional distribution of CHLa observations based on weekly monitoring during July-September in the tidal-fresh James.

Assessing Risk



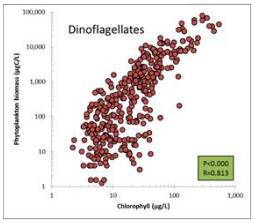


Current CHLa criterion for tidal fresh = 23 µg/L (Jul-Sep mean)

Candidate Metrics: Lower James

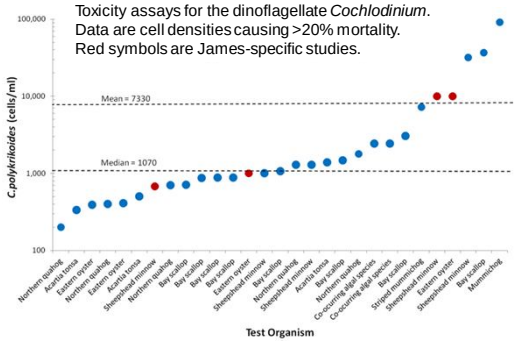
- Phytoplankton
  - Community evenness, IBI scores.
  - Abundance of harmful algae (*Cochlodinium*).
- Water Quality
  - Night-time dissolved oxygen minima, daytime pH maxima.
  - Transparency.

Cochlodinium polykrikoides

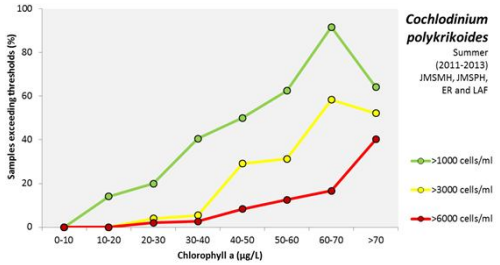


Assessing HAB Thresholds

Toxicity assays for the dinoflagellate *Cochlodinium*.
Data are cell densities causing >20% mortality.
Red symbols are James-specific studies.



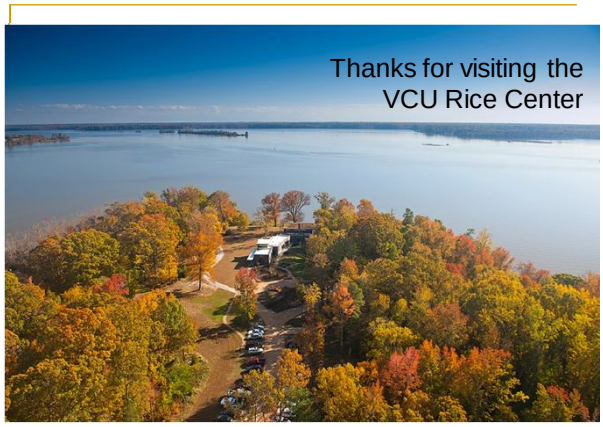
Dinoflagellate Blooms in Lower James



Likelihood of exceeding specified cell densities of Cochlodinium as a function of CHLa.

Summary of Progress

- Upper James Estuary (tidal fresh)
  - Data analysis largely completed.
  - All indicators support need for CHLa standards.
  - Current standards protective of designated uses.
- Lower James Estuary (saline)
  - Data analysis in progress.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